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A proactive/reactive approach to deal with disturbances in Volunteer Computing Platforms

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Outline

Introduction

State of the art

Adaptation of HEFT to the availability constraint

Stable algorithm for disturbed environments

More reactive approach

Validation and Empirical study

Conclusion

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Internet : a reserve of underexploited resources

Volunteering :

++ Many actors

++ Acceptable performance (technological evolution)

– Latent instability

– Short lived

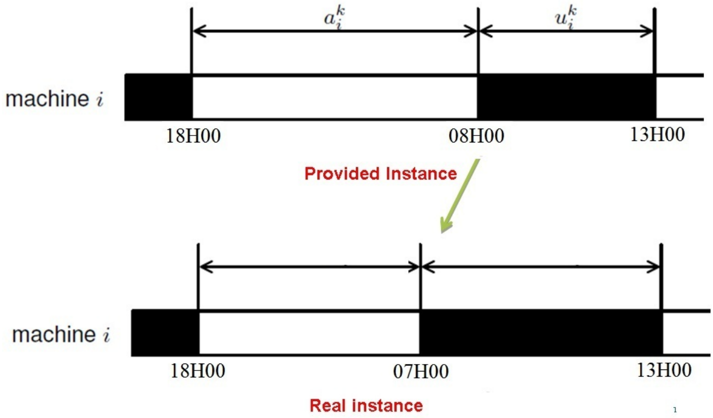
Collaboration :

++ Long-run (Institutional)

++ More or less – stable performance

– Not always evident to place

– Conflict of interest



a_i^k
u_i^k
machine i
18H00
08H00
13H00
Provided Instance
machine i
18H00
07H00
13H00
Real instance

Tasks, machines and objective :

- Tasks : n non preemptive independent tasks of cost p_j
- Machines
  - m machines having speed S_j
  - Machine j is only available during giving intevals
- Objective
  - Makespan (Taken uncertainty into account)
  - Stability : Not altered by disturbances

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Uncertainty sources : scheduling parameters

- Scheduling problem entries : Jobs (tasks), Processors (machines), structure (Communicatio, Arrival dates ....)
- Offline schedule : All the parameters are know in advance
- Online schedule: Not all parameters are known a priori
- Scheduling with uncertainties
  - We have prevision on data
  - No complete information

Uncertainty sources

- Destop grids : Uncertainty by nature (volunteer contribution, no control, ...)
- Uncertainty on dates, events,
- Cost (execution time) : depends to the real load
- Structure : Unpredicted tasks, task cancellation, task removal ....
- Communication structure
- Communication delay (correlated to network load)

Dealing with uncertainties

- Robust schedule : Not (or not very much) altered with disturbances

Resolution scheme

STEP 0 : Modelisation
STEP 1 : Static phase : Compute a set of feasible solution
STEP 2 : Dynamic phase : Compute the final (executed) solution

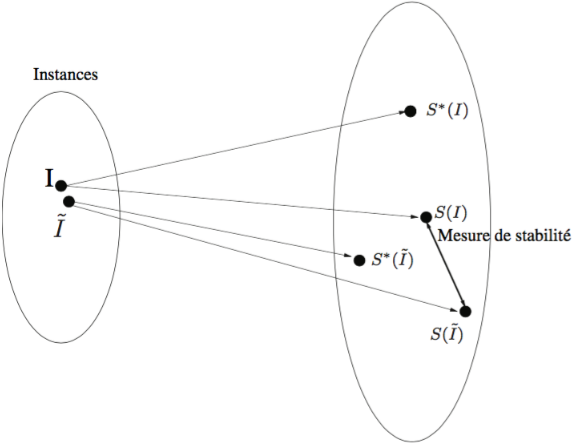
Resolution approach

- **Proactive**
  - Focus on Step 1
  - Design a reference or a set of reference schedules
  - Some **simple** adjustment may be done to keep the schedule feasible
- **Reactive**
  - Focus on Step 2
  - Most decisions are taken at the execution phase
  - Decisions may take long time to be taken
- **Procative/Reactive**
  - Proactive + Sophisticated reaction algorithm (phase 2)
  - Rectification and/or repotimisation

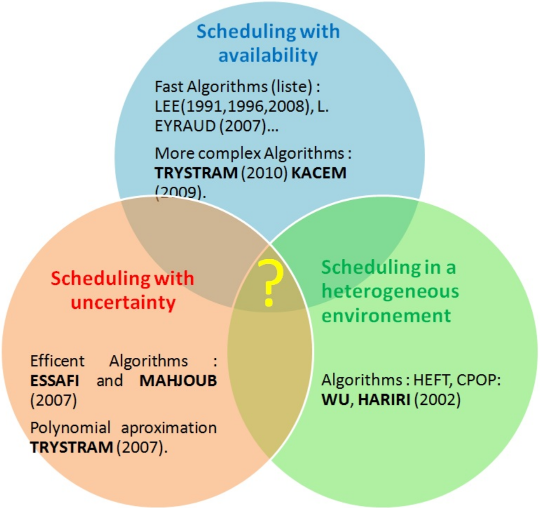
Performance

- Let I be the pretected instance and $\tilde{I}$ the disturbed one
- Let C^*_{max} and $\tilde{C}^*_{mac}$ be the optimal solutions for the predicted and distubed instances
- Let $C_{max}(A)$ and $\tilde{C}_{max}(A)$ the makespan
- Stability : $\rho = max_I \dfrac{\tilde{C}_{max}(A)}{C_{max}(A)}$
- Optimal stability is achieved when $\rho = 1$

Performance



Related work



HEFT principle for DAGs

Phase 1

- Calculation of the priority of each task ($rank_u$), which is based on the average calculation and communication costs.
- The task list is generated by sorting the tasks in decreasing order of $rank_u$.

Phase 2

HEFT Principle

HEFT principle for DAGs

Phase 1

- Calculation of the priority of each task ($rank_u$), which is based on the average calculation and communication costs.
- The task list is generated by sorting the tasks in decreasing order of $rank_u$.

Phase 2

- For most scheduling algorithms, the availability date for a processor p_j is the end of execution of its last task assigned.
- Insertion policy
- Possibility of insertion of a task in an interval of inactivity

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HEFT adaptation to availability constraint

- $EST(i,j) = avail(j,i)$: First date in which j can execute task i
- $EFT(i,j) = EST(i,j) + \frac{P_i}{S_j}$:End date of i task if executed on processor j
- $rank_u(i)$: Priority of the task i

HEFT-AC Algorithm

1. Compute the $Rank_u$ and the average cost of processing for all tasks
2. Sort all tasks in order of decreasing values of $Rank_u$.
3. **While** there are unscheduling tasks in the list **do**
5. Select the first task, n_i, from the list for scheduling
6. **For** each processor p_k in the processor-set ($p_k \in Q$) **do**
7. Compute the availablity date for n_i ($avail[p_k, n_i]$)
7. Compute EFT (n_i, p_k) value
8. Assign task n_i to the processor p_k that minimize EFT of task n_i.
9. **endwhile**

What's wrong with HEFT-AC ?

Risks

- Can fill an interval availability entirely
- Uncertainty unawareness ?

Improvement

- We must improve the allocation of tasks to machines using the availability model.

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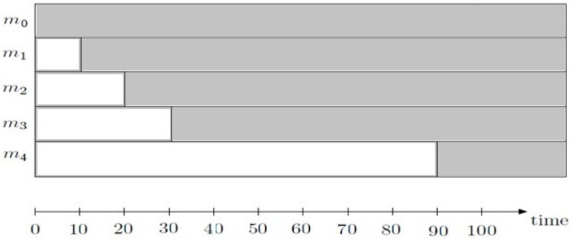
Performance modeling , Kondo et al.

- Identifying correlation between resources based on their availability
- Standard classification algorithm (K-means)
- They were able to identify 5 classes of machines

The average availability of a machine in a grid is a good criterion for the classification

Alpha

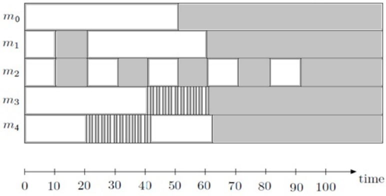
$$alpha[j] = \frac{\sum_{k=1}^{nb_{intervalles[j]}} a_j^k * vitesse[j]}{nb_{intervalles[j]}}$$



Is the average amount of computation in one interval

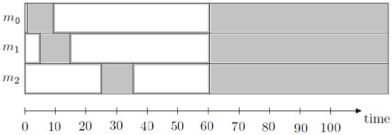
alpha[0]= 0
alpha[1]= 10
alpha[2]= 20
alpha[3]= 30
alpha[4]=90

Drawback whith Alpha



alpha[0]= 50
alpha[1]= 25
alpha[2]= 10
alpha[3]= 50/11 = 4.54
alpha[4]= 50/12 = 4.16

The alpha parameter does not take into account the dispersion pattern of intervals availability.



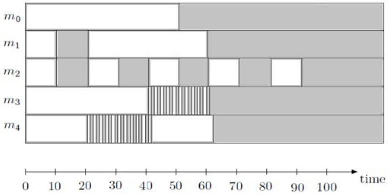
alpha[0]= 25
alpha[1]= 25
alpha[2]= 25

The alpha parameter is insufficient to characterize machines

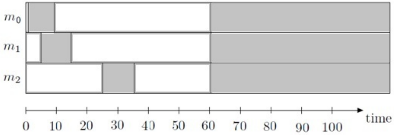
1

Beta

beta $[j]=\sum_{k=0}^{nb\_intervalles[j]}\left(a_j^k-\bar{l}[j]\right)^2$ **Is the variance between availability intervals of machine j**



Valeur de alpha	Valeur de beta
alpha[0]= 50	beta[0]=0
alpha[1]= 25	beta[1]=450
alpha[2]= 10	beta[2]=0
alpha[3]= 50/11 = 4.54	beta[3]=138.27
alpha[4]= 50/12 = 4.16	beta[4]=54.69



Valeur de alpha	Valeur de beta
alpha[0]= 25	beta[0]=1152
alpha[1]= 25	beta[1]=1058
alpha[2]=25	beta[2]=0

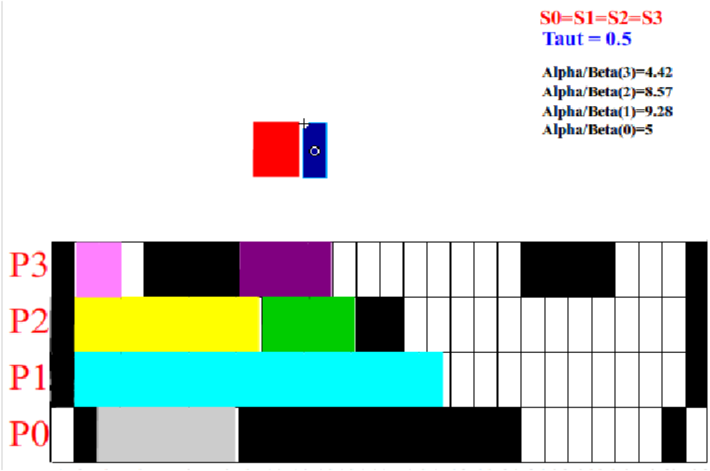
1

HEFT-ACU Algorithm

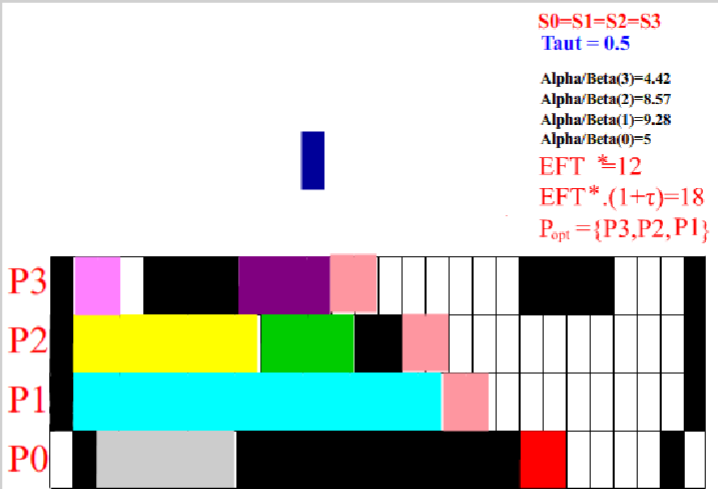
1. Compute the $Rank_u$ for all tasks
2. Compute alpha[j] and beta[j] for all processors.
3. Sort all tasks in order of decreasing values of $Rank_u$. (Longest First)
6. **While** there are unscheduled tasks in the list **do**
7. Select the first task, ni from the list
8. Compute $EFT^*(n_i) = Min_{j \in 1..m}(EFT\ (n_i, p_j)$
9. Let P_{cand} the list of processor p_j that $EFT\ (n_i, p_j) \leq EFT^*\ (n_i,)\ *(1+\tau)$
10. Assign task n_i to processor p_j from P_{cand} such as alpha[j] /beta[j] is the maximum
11. **endwhile**

Online execution : Adjustments to keep the schedule feasible

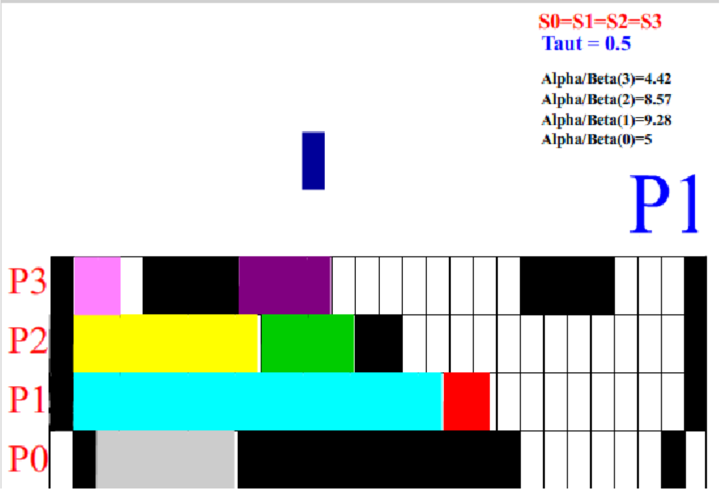
Exemple for Tasks allocation in HEFT-ACU



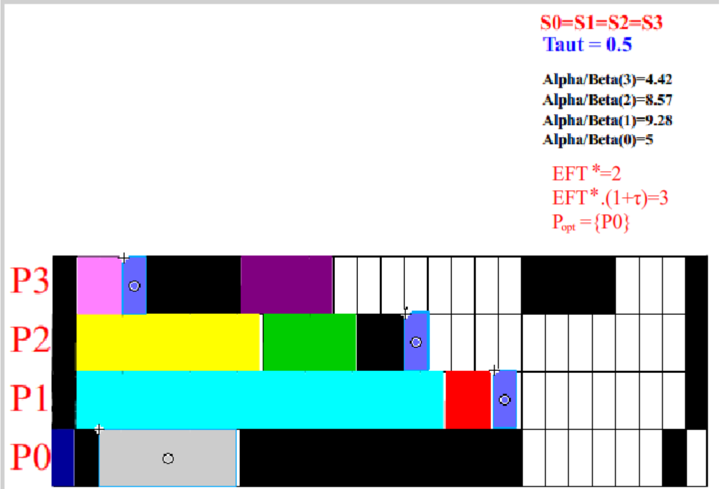
Exemple for Tasks allocation in HEFT-ACU



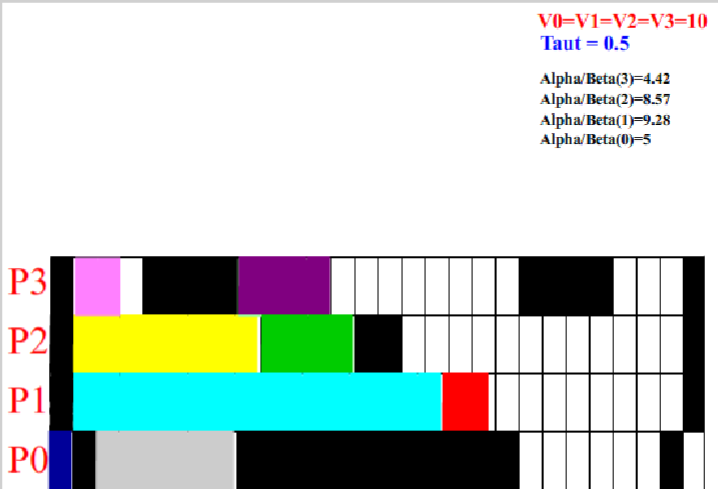
Exemple for Tasks allocation in HEFT-ACU



Exemple for Tasks allocation in HEFT-ACU



Exemple for Tasks allocation in HEFT-ACU



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Limits of the proactive approch

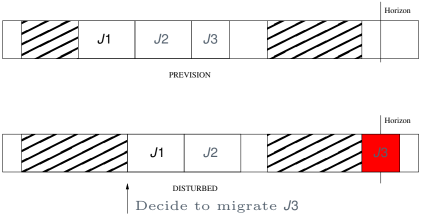
- Application : a set of tasks
- execution : all tasks must be executed
- No garentee : in disturbed environments
- Solution : Duplucate and/or migrate
- Our approach : Duplicate tasks if their completion time exceed a limit

Model

- Desktop grid
- No control on the host when unavailable
- No preemtion
- No migration cost (since the task will be sent from the broker to the worker)

Model

- For all machine j, Let $C^j = maxC_i$ for jobs i scheduled on machine j
- Define $horizon^j = \frac{3}{2}C^j$
- Purpose : In the disturbed execution, all tasks must be scheduled before $Horizon^j$



Target Processor

- At the begin of the current availability : identify jobs that exceeds $Horizon^j$
- Re-schedule these tasks to a new processor
- New processor is chosen in order to complete the tasks before *the horizon*
- Set of CL candidate processors
- Selection Criterion : Processor with highest stability (i.e $\frac{alpha}{beta}$)

Rescheduling tasks

- Phase 1 : Offline schedule (HEFT-AC)
- Phase 2 : Online execution with limited reaction mecanism base on delaying start execution time

Rescheduling tasks

- Phase 1 : Offline schedule (HEFT-AC)
- Phase 2 : Online execution with limited reaction mecanism base on delaying start execution time

Rescheduling tasks

- Phase 1 : Offline schedule (HEFT-AC)
- Phase 2 : Online Execution with sophisticated reaction mecanism
- Phase 3 : A decision of migrating the tasks is taken online
- Phase 3 : minimize the lateness of the completion time

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Execution Scenario

Scenario 1: (without disturbance) Tasks are executed using the planned dates.

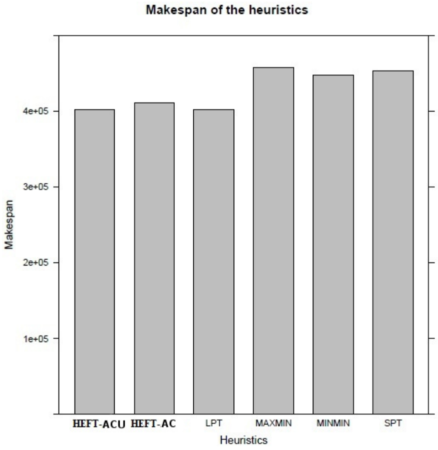
Scenario 2: (with disturbance) Potential interruptions of tasks are handled by a local re scheduling mechanism on the same processor.

We designed a specific simulator which supports machine profiles, task profile and disturbance in availability intervals

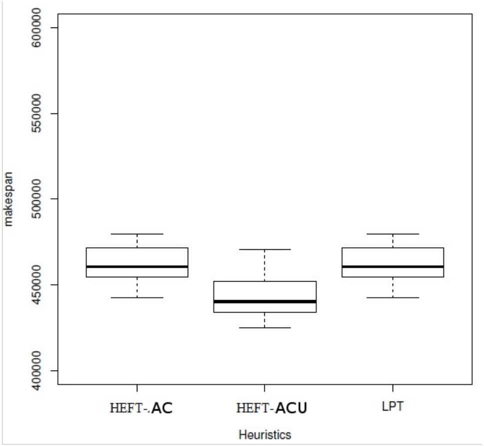
Study of performance of heuristics

- Six algorithms are studied :
  - LPT
  - SPT
  - MinMin
  - MaxMin
  - HEFT-AC
  - HEFT-ACU
- Test are performed on 10 different instances
  - 10000 tasks
  - 1000 machines
  - τ = 0.2 (empiricaly chosen)
  - Each instance is disturbed 30 times

Performance Comparison between Heuristics without disturbance



Performance Comparison between Heuristics with disturbance



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- We are considering uncertain Desktop grid platforms
- We adapted HEFT to schedule tasks within the schedule instead of only at the end
- We use the average and variance of the length of availability intervals to characterise the most stable machines
- HEFT-ACU is the most stable evaluated algorithm

Conclusion

- Limied reaction mecanism leads to non-executed jobs
- We moved from *proactive* approach, to a proactive/reactive approach
- Primary results : Migration improve distrubed makespan in disturbed envirnments with at least 5%

Some references ....

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The End

Thank you for your attention